**Construction**      iers

**T**he word aqueduct comes from the Latin words aqua - *water*, and ductum - *led*. Indeed it is a channel by which water is led from its source to the user. Most aqueducts ran underground. However, if it became necessary to cross a valley or river, the aqueduct was elevated on a bridge of stone arches that enabled the water flow at a constant rate. Depending on the topography, an aqueduct may have had to be constructed with multiple tiers of arches.  
.  
Not only were these structures functional, they were very impressive. The most photographed aqueduct today is the [Pont du Gard,](http://www.dl.ket.org/latin3/mores/aqua/pont.htm" \t "home) 25 miles from Nimes.

There are basically three types of aqueducts: masonry conduits, lead pipes, and [earthenware pipes](http://www.dl.ket.org/latin3/mores/aqua/pipe.htm" \t "home). The most common in Rome were masonry conduits. The nucleus of the masonry aqueduct was the specus, or the water channel. The specus was about the size of our present day doorway. The specus always had stone walls, stone floors, and a stone roof regardless if it ran underground or was built upon tiers. The specus was always covered. The purpose of the covering was originally to shield the channel from the sun. However, with the possibility of enemy intrusion through poisoning the water, the covering later became an important means of defense. These coverings were constructed of one of three types:

* [Flat slabs](http://www.dl.ket.org/latin3/mores/aqua/flat.htm" \t "home)
* [Twin slabs](http://www.dl.ket.org/latin3/mores/aqua/twin.htm" \t "home), a pointed arch
* [Half-round arch](http://www.dl.ket.org/latin3/mores/aqua/half.htm" \t "home)

Before construction could begin, the Romans had to find water. [The land which surrounded Rome](http://www.dl.ket.org/latin3/mores/aqua/countryside.htm" \t "home) was abundant with springs, which were fed by water from rain and melted snow that would seep into the earth. These springs were often hidden, so the Romans had to search for them underground. There were many methods for water detection. Vitruvius, a retired military engineer, gave several detection clues: "Just before sunrise, lie face downwards on the ground, resting your chin on your hands. Take a look over the countryside: where you see vapor curling up from the ground you will find water where you dig..." He also suggested placing a bronze bowl in a pit overnight. If the bowl had condensation in it in the morning, there was underground water. After water was found and the aqueduct was commissioned to be built, the Senate assessed the cost of construction. They decided which spring to tap and obtained a librator (surveyor) to design a practical route. The librator's first task was to find a route with a relatively even gentle slope, between the source and the city. The route was then marked with wooden stakes. When it was necessary to sight a straight run of aquaduct with an existing road or path, the surveyors might use a [groma](http://www.dl.ket.org/latin3/mores/aqua/groma.htm" \t "home) to determine the right angles. From this configuration other angles could also be set. The groma was used most often to set crossroad dimensions. After the source of the water and the city was determined, the liberator calculated the elevation of each end of the aqueduct. How did the librator actually make these measurements and calculations? A leveling instrument, [dioptra](http://www.dl.ket.org/latin3/mores/aqua/dioptra.htm" \t "home), was needed to take the measurements. This tool had a very limited sighting distance of about 40 yards and required the librator to move the tool up to hundreds of times over the distance of the proposed aqueduct. With the approximate length of the aqueduct and the difference in height between the source and the city, the librator could calculate the overall fall and begin marking the final route. Building could then start. While building an aqueduct, the men would be housed and fed in camps that were scattered along the route. Workers consisted of slaves, day laborers from small towns and unemployed workers from Rome. As may well be expected, slaves were found in the most grueling jobs such as tunneling and stone breaking.

Work on the aqueduct would begin concurrently at various points along the route. Every 20 yards [shafts](http://www.dl.ket.org/latin3/mores/aqua/shafts.htm" \t "home) were dug from the surface to the route of the aqueduct. At this time the roads for heavy equipment and animals would be constructed to expedite the slow transportation of stone. Soft ground would be trenched and the sides would be supported by [timber props](http://www.dl.ket.org/latin3/mores/aqua/timber.htm" \t "home). Often times the trenching would run through stone, hence the hewn stone had to be hauled out in baskets up shafts. At every stage the librators checked the progress. Once a channel had been roughed out, a [chorobates](http://www.dl.ket.org/latin3/mores/aqua/choro.htm" \t "home) would be lowered into the trench to check the slope. If the choborate was too large to lower into the shaft, the alternate method was to observe water levels.

Arches were created by the use of [wooden supports](http://www.dl.ket.org/latin3/mores/aqua/woodsupp.htm" \t "home) that created the shape of the arch and were removed after construction. The water channel was often lined with [concrete](http://www.dl.ket.org/latin3/mores/aqua/concrete.htm" \t "home). Yes, the Romans did use concrete, a combination of stones of varying sizes held together with mortar made of sand, lime and water. The finished aqueduct would run across the [terrain](http://www.dl.ket.org/latin3/mores/aqua/terrain.htm" \t "home) at a slight incline that allowed the water to flow slowly to its destination.

Water could be diverted from an aqueduct into other channels by creating [cisterns](http://www.dl.ket.org/latin3/mores/aqua/cistern.htm" \t "home). The main flow could continue while some of the water was sent through small openings to supply baths or fountains. At the terminus of the aqueduct, a huge cistern would hold the water until it was needed. When visiting Misenum at the end of the north eastern edge of the bay of Naples, one can see the [Piscina Mirabilis](http://www.dl.ket.org/latin3/mores/aqua/piscina.htm" \t "home) which held the fresh water supply for the Roman fleet.

Once complete and working, aqueducts had long working histories. They were maintained, inspected, repaired and improved. For example, chalk [deposits](http://www.dl.ket.org/latin3/mores/aqua/deposits.htm" \t "home) built up and would decrease water supply and eventually block the aqueduct. Consequently, the channels, as well as the traps, had to be cleaned regularly for sediment deposits. It was necessary to build accesses at regular intervals to facilitate the cleaning. As the wars in Italy ended it was no longer necessary for the channels to be secret. Many were marked with milestones called cippi. Cippi were used to locate specific points along the aqueduct making these repairs practical. The business of aqueduct regulation became a venture. Private and commercial consumers paid for their water, but it was common to steal water by connecting a pipe to the aqueduct. Curator Aquarum - Frontinus became a "water commissioner" to guard against people piping water directly into their homes without permission of the emperor, or drawing off public water. Pipe sizes were regulated and the pipes were stamped and recorded to ensure no larger pipes were installed later. Ordinary people were permitted to draw water from street fountains. It was of great importance that the water for these [street fountains](http://www.dl.ket.org/latin3/mores/aqua/fountain3.htm" \t "home) and the public baths be protected.